SPACE TRANSPORTATION SYSTEM 98 (STS-98)

Introduction and Background

The JSC Toxicology Group, as part of its program to ensure a toxicologically safe environment during Space Shuttle missions, analyzes samples of cabin air taken during each mission. These procedures help determine the effectiveness of contamination control measures that are designed to maintain a safe internal environment during missions.

Sampling and Analysis

Samples of cabin air were taken in evacuated grab-sample canisters (GSCs) immediately before launch, and at MET 10/13:24 from the middeck area. The samples were sent to the JSC Toxicology Laboratory for analysis by gas chromatography and mass spectrometry (GC/MS) according to methods described in applicable work instructions.

A toxicological evaluation of the air requires that spacecraft maximum allowable concentrations (SMACs) of every component of the mixture of contaminants be considered rather than the concentration of each individual contaminant. The potential toxicity (T) of the mixture of "n" airborne contaminants in each sample was determined by adding the ratios of each concentration (C) to the appropriate 7-day SMAC. The 7-day SMACs were used in the calculation because the length of the mission was closer to 7 days than 30 days. The equation is shown below:

$$T = C_1/SMAC_1 + C_2/SMAC_2 + ...C_n/SMAC_n$$

Values of "T" below 1.0 for each toxicological category (e.g. irritants, cardiotoxicants, etc) indicate that the mixture of contaminants measured in the air was toxicologically safe to breathe at the time and place of sampling.

Data were made available to the Toxicology Group by the Crew and Thermal Systems Division on their measurements of carbon dioxide in the middeck. Their method employs an electrochemical sensor to quantify carbon dioxide on a nearly continuous basis.

Results and Discussion

Canister Sample Results

Analytical results from the canister samples and calculated T values are shown in tables 1 and 2, respectively. Results of replicate analyses of the flight sample are reported in table 3, and recoveries of surrogate standards are reported in table 4. Except for an unidentified C15 alkane, the relative percent differences were less than 10 % for the replicates, and the recoveries of acetone, fluorobenzene, and chlorobenzene surrogates ranged from 81 to 97 %, which is within acceptable limits for quality assurance. The results in table 2 show that the air met NASA’s standards for air quality even without

separation of carbon dioxide from other compounds that contribute to toxicological groups (T_{group} <1). Carbon dioxide, which contributed1/2 of the total T-value of 0.61, acts independently of other air pollutants, so it does not contribute to any of the traditional toxicological groups (e.g. irritants, carcinogens, neurotoxicants, etc).

Carbon Dioxide Measurements

The carbon dioxide concentrations in the middeck during the mission are shown in the figure. The carbon dioxide concentrations, as measured with the electrochemical sensors, averaged about 1.5 mmHg during the flight and showed a range from 0.6 to 2.8 mmHg. The average daily concentrations were well within the time-weighted-average SMAC of 5.3 mmHg for missions lasting several days. The circle in the figure represents measurement of carbon dioxide made by the Toxicology Laboratory on the canister sample taken during the mission. The GSC-sample concentration of 4200 mg/m3 (1.8 mmHg) was close to the electrochemical-sensor concentration (1.8 mmHg) at the time of measurement.

Conclusion

Based on assessments of an air sample from the middeck taken late in the mission, I conclude that during the STS-98 flight of *Atlantis*, the air was toxicologically safe to breathe.

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Enclosures

1: Analytical Results of STS-98 Air Samples

2: T Values of STS-98 Air Samples

TABLE 1
ANALYTICAL RESULTS OF
STS-98 CONTAINER AIR SAMPLES

CHEMICAL CONTAMINANT	CONCENTRATION (mg/m3)	
	AA02992 S/N1004 PREFLIGHT 2/7/01@12:15EST	**AA03006 S/N1018 MIDDECK MET 10\13:24 (2/18/01 @ 12:38GMT)**
TARGET COMPOUNDS (TO-14/POLAR)		
DICHLORODIFLUOROMETHANE	* <0.050	0.12
CHLOROMETHANE	<0.050	TRACE
1,2-DICHLORO-1,1,2,2-TETRAFLUOROETHANE	<0.050	<0.050
ACETALDEHYDE	#TRACE	0.14
METHANOL	TRACE	0.15
VINYL CHLORIDE	<0.050	<0.050
BROMOMETHANE	<0.050	<0.050
ETHANOL	TRACE	7.3
CHLOROETHANE	<0.050	TRACE
ACETONITRILE	TRACE	TRACE
PROPENAL	<0.020	<0.020
ACETONE	TRACE	0.25
PROPANAL	TRACE	TRACE
ISOPROPANOL	0.08	0.23
TRICHLOROFLUOROMETHANE	<0.050	<0.050
FURAN	<0.050	<0.050
ACRYLONITRILE	<0.050	<0.050
PENTANE	<0.050	<0.050
2-METHYL-2-PROPANOL	<0.050	TRACE
METHYL ACETATE	<0.050	<0.050
1,1-DICHLOROETHENE	<0.050	<0.050
DICHLOROMETHANE	<0.050	0.44
3-CHLOROPROPENE	<0.050	<0.050
1,1,2-TRICHLORO-1,1,2-TRIFLUOROETHANE	<0.050	<0.050
N-PROPANOL	<0.050	TRACE
1,1-DICHLOROETHANE	<0.050	<0.050
BUTANAL	TRACE	TRACE
2-BUTANONE	TRACE	TRACE
1,2-DICHLOROETHENE	<0.050	<0.050
2-METHYLFURAN	<0.050	<0.050
ETHYL ACETATE	<0.050	<0.050
HEXANE	<0.050	<0.050
CHLOROFORM	<0.050	<0.050
2-BUTENAL	<0.050	<0.050
1,2-DICHLOROETHANE	<0.050	<0.050
1,1,1-TRICHLOROETHANE	<0.050	<0.050
N-BUTANOL	TRACE	TRACE
BENZENE	<0.050	<0.050
CARBON TETRACHLORIDE	<0.050	<0.050
2-PENTANONE	<0.050	<0.050
PENTANAL	TRACE	TRACE
1,2-DICHLOROPROPANE	<0.050	<0.050
1,4-DIOXANE	<0.050	<0.050
TRICHLOROETHENE	<0.050	<0.050
2,5-DIMETHYLFURAN	<0.050	<0.050
4-METHYL-2-PENTANONE	<0.050	TRACE
CIS-1,3-DICHLOROPROPENE	<0.050	<0.050
2-PENTENAL	<0.050	<0.050

CHEMICAL CONTAMINANT	CONCENTRATION (mg/m3)	
	AA02992 S/N1004 PREFLIGHT 2/7/01@12:15EST	**AA03006 S/N1018 MIDDECK MET 10\13:24 (2/18/01 @ 12:38GMT)**
TARGET COMPOUNDS (TO-14/POLAR)		
TRANS-1,3-DICHLOROPROPENE	<0.050	<0.050
1,1,2-TRICHLOROETHANE	<0.050	<0.050
TOLUENE	<0.050	TRACE
HEXANAL	TRACE	TRACE
MESITYL OXIDE	<0.050	<0.050
1,2-DIBROMOETHANE	<0.050	<0.050
BUTYL ACETATE	<0.050	<0.050
TETRACHLOROETHENE	<0.050	<0.050
CHLOROBENZENE	<0.050	<0.050
ETHYL BENZENE	<0.050	<0.050
M- + P-XYLENES	<0.050	TRACE
2-HEPTANONE	<0.050	<0.050
CYCLOHEXANONE	<0.050	TRACE
HEPTANAL	TRACE	TRACE
STYRENE	<0.050	<0.050
1,1,2,2-TETRACHLOROETHANE	<0.050	<0.050
O-XYLENE	<0.050	<0.050
1,3,5-TRIMETHYLBENZENE	<0.050	<0.050
1,2,4-TRIMETHYLBENZENE	<0.050	<0.050
1,3-DICHLOROBENZENE	<0.050	<0.050
1,4-DICHLOROBENZENE	<0.050	<0.050
1,2-DICHLOROBENZENE	<0.050	<0.050
1,2,4-TRICHLOROBENZENE	<0.050	<0.050
HEXACHLORO-1,3-BUTADIENE	<0.050	<0.050
TARGET COMPOUNDS (TOXIC)		
1,3-BUTADIENE	<0.050	<0.050
ETHYLENE OXIDE	<0.050	<0.050
CARBON DISULFIDE	<0.050	TRACE
2-METHYL-2-PROPENAL	<0.050	<0.050
3-BUTEN-2-ONE	<0.050	<0.050
DIMETHYLDISULFIDE	<0.050	<0.050
2-ETHOXYETHANOL	<0.050	<0.050
OCTAMETHYLCYCLOTETRASILOXANE ***	*0.18*	*1.3*
NON-TARGET COMPOUNDS		
OCTAFLUOROPROPANE	& BL	6.7
BROMOTRIFLUOROMETHANE	BL	0.61
HEXAMETHYLCYCLOTRISILOXANE ***	*0.45*	*1.0*
DECAMETHYLCYCLOPENTASILOXANE ***	*0.07*	*1.8*
C-15 ALKANE	BL	0.23
TARGET COMPOUNDS (GC)		
ETHYLENE	ND	ND
CARBON MONOXIDE	ND	1.8
METHANE	TRACE	71
HYDROGEN	ND	3.1
CARBON DIOXIDE	1700	4200
TOTAL CONCENTRATION (NON-METHANE HYDROCARBONS)	0.78	20

CHEMICAL CONTAMINANT	CONCENTRATION (mg/m3)	
	AA02992 S/N1004 PREFLIGHT 2/7/01@12:15EST	**AA03006 S/N1018 MIDDECK MET 10\13:24 (2/18/01 @ 12:38GMT)**
TARGET COMPOUNDS (TO-14/POLAR)		

* < : Value is less than the laboratory report detection limit.

TRACE: Amount detected is sufficient for compound identification only. Calculations are based on one-half of the laboratory report detection limit (1.1 mg/m3 for CO; 0.65 mg/m3 for CH4; 0.41 mg/m3 for H2; 0.05 mg/m3 for VOCs; and 0.02 mg/m3 for propenal.)

& BL: Area below the search routine limit (<20% of the fluorobenzene peak area).

***Siloxane compounds are common contaminates and measurements are not under statistical control.

	(0.78+0.3=1.08) (12Traces = 0.3)	**(19.99+0.425=20.42)** (17 Traces = 0.425)
# OF TRACE	12	17
SUBTOTAL CONCENTRATION	0.78	20

TABLE 2
ANALYTICAL RESULTS OF
STS-98 CONTAINER AIR SAMPLES

CHEMICAL CONTAMINANT	T-VALUE	
	AA02992 S/N 1004 PREFLIGHT 2/7/01@12:15EST	AA03006 S/N 1018 MIDDECK MET 10\13:24 (2/18/01 @ 12:38GMT)
TARGET COMPOUNDS (TO-14/POLAR)		
DICHLORODIFLUOROMETHANE	*ND	0.00024
CHLOROMETHANE	ND	0.00061
1,2-DICHLORO-1,1,2,2-TETRAFLUOROETHANE	ND	ND
ACETALDEHYDE	0.00278	0.01528
METHANOL	0.00625	0.03855
VINYL CHLORIDE	ND	ND
BROMOMETHANE	ND	ND
ETHANOL	0.00001	0.00366
CHLOROETHANE	ND	0.00010
ACETONITRILE	0.00373	0.00373
PROPENAL	ND	ND
ACETONE	0.00050	0.00491
PROPANAL	0.00175	0.00175
ISOPROPANOL	0.00052	0.00156
TRICHLOROFLUOROMETHANE	ND	ND
FURAN	ND	ND
ACRYLONITRILE	ND	ND
PENTANE	ND	ND
2-METHYL-2-PROPANOL	ND	0.00021
METHYL ACETATE	ND	ND
1,1-DICHLOROETHENE	ND	ND
DICHLOROMETHANE	ND	0.00878
3-CHLOROPROPENE	ND	ND
1,1,2-TRICHLORO-1,1,2-TRIFLUOROETHANE	ND	ND
N-PROPANOL	ND	0.00026
1,1-DICHLOROETHANE	ND	ND
BUTANAL	0.00141	0.00141
2-BUTANONE	0.00083	0.00083
1,2-DICHLOROETHENE	ND	ND
2-METHYLFURAN	ND	ND
ETHYL ACETATE	ND	ND
HEXANE	ND	ND
CHLOROFORM	ND	ND
2-BUTENAL	ND	ND
1,2-DICHLOROETHANE	ND	ND
1,1,1-TRICHLOROETHANE	ND	ND
N-BUTANOL	0.00031	0.00031
BENZENE	ND	ND
CARBON TETRACHLORIDE	ND	ND
2-PENTANONE	ND	ND
PENTANAL	0.00118	0.00118
1,2-DICHLOROPROPANE	ND	ND
1,4-DIOXANE	ND	ND
TRICHLOROETHENE	ND	ND
2,5-DIMETHYLFURAN	ND	ND
4-METHYL-2-PENTANONE	ND	0.00018
CIS-1,3-DICHLOROPROPENE	ND	ND
2-PENTENAL	ND	ND

CHEMICAL CONTAMINANT	T-VALUE	
	AA02992 S/N 1004 PREFLIGHT 2/7/01@12:15EST	AA03006 S/N 1018 MIDDECK MET 10\13:24 (2/18/01 @ 12:38GMT)
TARGET COMPOUNDS (TO-14/POLAR)		
TRANS-1,3-DICHLOROPROPENE	ND	ND
1,1,2-TRICHLOROETHANE	ND	ND
TOLUENE	ND	0.00042
HEXANAL	0.00102	0.00102
MESITYL OXIDE	ND	ND
1,2-DIBROMOETHANE	ND	ND
BUTYL ACETATE	ND	ND
TETRACHLOROETHENE	ND	ND
CHLOROBENZENE	ND	ND
ETHYL BENZENE	ND	ND
M- + P-XYLENES	ND	0.00011
2-HEPTANONE	ND	ND
CYCLOHEXANONE	ND	0.00042
HEPTANAL	0.00089	0.00089
STYRENE	ND	ND
1,1,2,2-TETRACHLOROETHANE	ND	ND
O-XYLENE	ND	ND
1,3,5-TRIMETHYLBENZENE	ND	ND
1,2,4-TRIMETHYLBENZENE	ND	ND
1,3-DICHLOROBENZENE	ND	ND
1,4-DICHLOROBENZENE	ND	ND
1,2-DICHLOROBENZENE	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND
HEXACHLORO-1,3-BUTADIENE	ND	ND
TARGET COMPOUNDS (TOXIC)		
1,3-BUTADIENE	ND	ND
ETHYLENE OXIDE	ND	ND
CARBON DISULFIDE	ND	0.00156
2-METHYL-2-PROPENAL	ND	ND
3-BUTEN-2-ONE	ND	ND
DIMETHYLDISULFIDE	ND	ND
2-ETHOXYETHANOL	ND	ND
OCTAMETHYLCYCLOTETRASILOXANE	0.00064	0.00453
NON-TARGET COMPOUNDS		
OCTAFLUOROPROPANE	& BL	0.00008
BROMOTRIFLUOROMETHANE	BL	0.00006
HEXAMETHYLCYCLOTRISILOXANE	0.00501	0.01156
DECAMETHYLCYCLOPENTASILOXANE	0.00047	0.01173
C15 ALKANE	BL	0.00054
TARGET COMPOUNDS (GC)		
ETHYLENE	ND	ND
CARBON MONOXIDE	ND	0.15253
METHANE	0.00094	0.01878
HYDROGEN	ND	0.00092
CARBON DIOXIDE	0.13067	0.32121
TOTAL T-VALUE	0.15893	0.60991

CHEMICAL CONTAMINANT	T-VALUE	
	AA02992 S/N 1004 PREFLIGHT 2/7/01@12:15EST	AA03006 S/N 1018 MIDDECK MET 10\13:24 (2/18/01 @ 12:38GMT)
TARGET COMPOUNDS (TO-14/POLAR)		

* ND : Value is less than the laboratory report detection limit.

& BL: Area below the search routine limit (<20% of the fluorobenzene peak area).